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REMOTE SENSING IN MICHIGAN FOR LAND RESOURCE MANAGEMENT:
Waterfowl Habitat Management at Pointe Mouillee

by

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16. Abstract

For many years the Pointe Mouillee State Game Area, located on the Lake Erie shoreline just south of Detroit, has been a prime waterfowl habitat. The usefulness of the site for this purpose has been impaired because of the gradual deterioration of the marshland and severe flooding and storms during the spring of 1973. Also, it has been proposed that a dredge spoils area be located in or near the marsh.

In order to help solve the problems affecting Pointe Mouillee, the Environmental Research Institute of Michigan (ERIM) and Michigan State University (MSU) jointly undertook an investigation which emphasized the use of data acquired by remote sensing methods.

To aid the future management of a diked refuge area of 148 hectares within the State Game Area, a detailed vegetation inventory was prepared by photointerpretation and a generalized vegetation inventory was obtained by processing multispectral scanner imagery.

Also, an analysis was conducted to determine the magnitude of past losses of marshland and the possibilities of replacing this lost habitat. The analysis indicated that large additions to waterfowl habitat could be provided by changes in

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management of vegetation in existing sections of the State Game Area, through acquisition and conversion of adjacent land by the Michigan Department of Natural Resources, and by the proposed construction of a barrier dike offshore of Pointe Mouillee. Altogether, the various measures considered in this report could affect a total area of nearly 13 sq. km.

PREFACE

This project was performed for the Office of University Affairs, National Aeronautics and Space Administration, by the Environmental Research Institute of Michigan (ERIM) in cooperation with Michigan State University (MSU). The Environmental Research Institute of Michigan is a non-profit corporation which was established on 1 January 1973 as successor to the Willow Run Laboratories of The University of Michigan.

This report is one of a series presenting the results of a program to develop and apply earth resource survey technology to land resource management problems of current concern to public agencies in Michigan. Joseph A. Vitale, Chief, Engineering Design Branch, Office of University Affairs, acts as the NASA Technical Monitor for this program.

The work performed at ERIM was carried out on NASA Grant NGR 23-005-552 under the direction of Donald S. Lowe, Deputy Director of the Infrared and Optics Division. The work at MSU was carried out on NASA Grant NGL 23-004-083. At MSU, direction was provided by Myles G. Boylan, Director of the School of Urban Planning and Landscape Architecture, and Dr. Raymond D. Vlasin, Chairman of the Department of Resource Development.

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1
SUMMARY

Pointe Mouillee, containing the State Game Area that bears its name, is located at the mouth of the Huron River on the Lake Erie shoreline just south of Detroit. For generations this low-lying area has been a prime waterfowl habitat, situated as it is on two important migration corridors for ducks and geese. In late years, however, the site's usefulness for this purpose has been impaired through gradual deterioration of marshland in the river estuary and, more recently, because of severe flooding incurred as a result of storms experienced during the fall of 1972 and spring of 1973. To add to these adversities, dredge-spoils sites have been proposed for the immediate area. Other changes in land use or environmental factors which could affect the marsh are encroaching urban development and possible location of a regional wastewater treatment plant in the vicinity. (See Section 2.)

Thus, the viability of the Pointe Mouilee State Game Area is being seriously threatened by both natural influences and man's activities. Unless action is taken within the next few years, the habitat will cease to function as a recreation area for hunters and will continue to decline in value as a waterfowl refuge.

To help solve the problems affecting Pointe Mouillee, the Environmental Research Institute of Michigan (ERIM) and Michigan State University (MSU) jointly undertook an investigation which emphasized the use of data acquired by remote sensing methods.

One major objective was to provide detailed information needed for improved management of waterfowl food and cover vegetation in the State Game Area (see Section 3). For the actively managed diked area of 148 hectares within the State Game Area, both a detailed vegetation inventory prepared by photointerpretation and a generalized vegetation inventory obtained by processing multispectral scanner imagery were prepared. These products provided information needed for modifying management practices in the area, served as a data base for checking future changes, and afforded a means of recording and communicating information to other game management personnel, supervisory personnel, and the general public.

Another major objective of the investigation was to determine the magnitude of marshland losses (see Section 4) and look into the possibilities of replacing this lost habitat (see Section 5). This analysis indicated that large additions to waterfowl habitat could be provided—by changes in vegetation management in existing sections of the Pointe Mouillee State Game Area, by Department of National Resources (DNR) acquisition and conversion of adjacent land, and by the proposed construction of a barrier dike offshore of Pointe Mouillee. Altogether, the total area that could be affected by the various measures considered in this report amounts to nearly 13 sq. km. Through further study it can be determined which measures, applied singly or in combination, would prove most economical and effective in replacing lost habitat.

This investigation has been conducted in close cooperation with Mr. James Foote, Game Biologist for the Department of Natural Resources stationed at the Pointe Mouillee State Game Area. Mr. Foote has been extremely helpful in providing information concerning the operating practices and information requirements needed for successful management of the area, assisting with the collection of ground truth, and evaluating the data obtained through remote sensing.

Preliminary copies of this report were made available to DNR staff members representing the Hydrological Survey Division, the Wildlife Division, and the Region III (Southern Michigan) Office. DNR is currently working with the U.S. Army Corps of Engineers to develop and evaluate a plan for the construction at Pointe Mouillee of a protective dike which will allow rejuvenation of the marsh area and provide a safe site for disposal of material dredged from the Detroit and Rouge Rivers. The pictorial and analytical information contained herein on past losses and potential additions of marsh habitat has been used to analyze the potential value and environmental impact of the proposed barrier dike. As the dike is completed, this information will continue to be useful in planning marsh rejuvenation and management activities.

2
MANAGEMENT OBJECTIVES AT POINTE MOUILLEE

2.1 SITE DESCRIPTION

The Pointe Mouillee State Game Area is located on the delta and estuarine area of the Huron River as it enters Lake Erie just south of Detroit (Fig. 1). The game area, which presently consists of more than 1100 hectares of publicly owned land and water, is both an important feeding and resting area on migration routes for waterfowl and one of the few duck hunting areas in Southeast Michigan. Like all estuarine habitats, it plays a vital role in maintaining the bioproductivity of the lake.

Centrally located along the Mississippi Flyway, the marsh is used by waterfowl primarily as a resting and feeding stop during migration. Only a few species regularly nest there, among them mallards, blue wing teal, gallinules, and rails. Occasionally, numbers of mallards stay throughout the winter. In addition, the marsh is an important habitat for muskrats and other marsh-associated birds and mammals, and the river mouths serve as spawning areas for many fish.

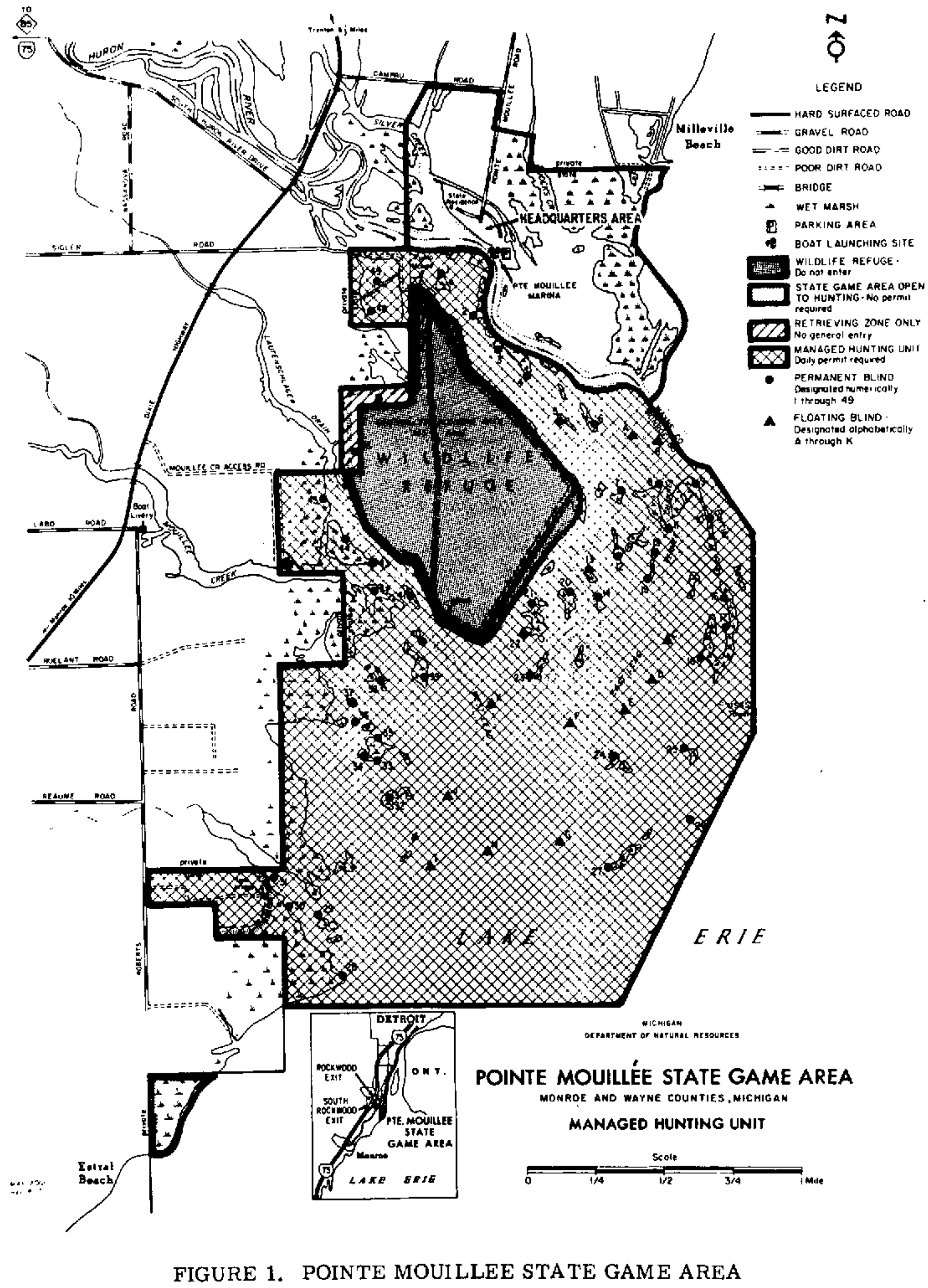


FIGURE 1. POINTE MOUILLEE STATE GAME AREA

Since most birds use the Pointe Mouillee marsh only as a migration stopping place, management of the area focuses on maintaining a large standing crop of quality waterfowl foods to attract enough birds to withstand the heavy hunting pressure on the area. Smartweeds (Polygonum), pigweed (Amaranthus) and burreed (Sparganium), the major emergent food plants at Pointe Mouillee, are best propagated in management areas where the water level is controllable. Rushes (Scirpus) also serve as food, as well as cover. Cattails (Typha), which are the predominant cover type, tend to dominate the marsh if they are not excluded by management practices. Their natural growth usually supplies the necessary cover areas.

Within the State Game Area, a large diked area of 148 hectares is actively managed as a wildlife refuge. Pumping units regulate the water level within the dike. The area is drained in late spring so that food for the ducks can grow and mature; in the fall it is flooded.

2.2 INVESTIGATION OBJECTIVES TO AID MANAGEMENT DECISIONS

2.2.1 IMPROVEMENTS IN MANAGEMENT PRACTICES

In order to support and increase the number of waterfowl using the game area, the marshland must be managed in such a manner that the production of vegetation needed for food and cover is maximized. This project provided information needed for monitoring and improving vegetative growth in the actively managed area within the dike.

Information is needed for both short-range and long-range management of the area. Over the short range, the extant carrying capacity of the area and the immediate management steps needed to maintain the supply of food and cover can be obtained from a vegetation inventory. Over the longer range, however, the manager's problem is to improve his management of the food and cover vegetation through a better knowledge of ecological factors affecting plant succession, growth, and destruction. Careful observation of changes associated with varying management practices over a period of several years can lead to the adoption of improved techniques.

There is also a need for a complete record of vegetation growth and change over prolonged periods of time. This is particularly important in the event of changes in management personnel, since it will ensure the adequate transfer of information. The vegetation inventory prepared under this project goes a long way toward providing this needed record.

Finally, quantitative and pictorial information in the possession of the wildlife manager can serve as graphic evidence for dissemination to other technical and administrative personnel as well as to the public when their support is needed.

2.2.2 EVALUATION OF HABITAT LOSS

Of primary concern to Michigan's Department of Natural Resources is the rapid destruction of land and marsh habitat in the river estuary at Pointe Mouillee. One possible reason for this destruction is that the construction of dams along the Huron River has cut off the supply of silt which previously maintained and enriched the islands and marshes in the estuary. High water driven into the mouth of the river by east winds during the spring has uprooted the cattails and washed away the islands. This storm damage was particularly severe during the winter and spring of 1972-73 because of abnormally high water levels in Lake Erie. As a result of these natural forces, the controlled diked area now contains more than half the remaining marsh habitat within the State Game Area. In order to document this continuing loss of waterfowl habitat and to assess its impact on the continued use of the marsh, remote sensing data were used to measure changes in the marsh beginning as far back as 1935.

Various human activities also threaten the continued operation of the State Game Area. The Game Area has been under pressure in recent years from encroaching residential development. During the 1960's, moreover, the construction of large manufacturing complexes in the immediate vicinity was proposed. Other changes in land use or in environmental factors affecting the marsh area may result from the construction of a proposed thermal power plant, a regional wastewater treatment plant, and a dumping site for materials dredged from the Detroit and Rouge Rivers. The construction of a dumping site was under active consideration at the time of this investigation, and because of the long-range implications for the future of the State Game Area, a major focus of the investigation was to prepare and present information bearing on the site-selection decision.

When the Pointe Mouillee investigation first started, it was anticipated that the Army Corps of Engineers would use State-owned marshlands north of the Huron River as the site for dumping dredge spoil material. This site included 80 hectares of land which had been acquired by the DNR to buffer their major marsh areas from the potential industrial development of nearby lands and adjacent water areas. Once the site was filled, it would be turned over to the Huron Clinton Metropolitan Authority for construction of a park. During public consideration of the plan, members of our project team presented information on the amount and quality of existing marshland which would be filled. Because of public concern over this loss of natural marshland and over the possible environmental effect of dumping polluted material with an appreciable mercury content, the Corps of Engineers eventually tabled this initial plan.

2.2.3 PROTECTION AND EVALUATION OF NEW MARSHLAND

At present, another plan is under joint consideration by the Corps of Engineers and the Department of Natural Resources. Under this new plan, a long barrier dike would be constructed offshore of the marsh, both to provide a containment area for the materials dredged from the Detroit and Rouge Rivers and to protect the remaining marshland while allowing eroded areas to be rebuilt. Our project has furnished information on the current condition and extent of marsh areas which this planned barrier dike would either protect or allow to be rejuvenated.

The construction of a barrier dike represents a long-term solution to the problem of returning Pointe Mouillee to its original usefulness. A more immediate approach that complements the long-range potential of the barrier dike is to convert existing uplands along the shore to waterfowl habitat. The Michigan Department of Natural Resources wants to increase its ownership in the Pointe Mouillee area by purchasing land adjacent to their present holdings. Our analysis included information on the amount and suitability of those lands available for conversion to waterfowl habitat.

2.3 INVESTIGATION DESIGN

Our investigation of the Pointe Mouillee State Game Area included data acquisition, processing, and analysis. During the data-acquisition phase, aerial photography, multispectral scanner imagery, and ground-truth data were collected. Also, a preliminary bibliography of specific information on Pointe Mouillee and general information on current wetland-assessment methods were compiled for use during the phase of data interpretation and analysis.

Aerial photography used in the study included high-altitude vertical photography, low-altitude vertical photography, and low-altitude oblique photography. High-altitude photography was available from three RB-57 flights (1969, 1971, and June 1972). The high-resolution quality of this photography allowed enlargements from which a photo-map substitute was produced for reference purposes. The photography was also useful for shoreline delineation and for coverage of upland areas around Pointe Mouillee.

Low-altitude oblique photography with three hand-held cameras was obtained by means of a helicopter flight. This photography, taken at scales ranging from 1:1800 to 1:7200, was used as a supplement to smaller-scale photography when the scale or type of the latter film prevented accurate interpretation of a specific target. It was also useful in specifying operational mission requirements for photography collected in August 1972 during the C-47 flight discussed below. We also obtained photographic coverage from other sources, such as the Department of Natural Resources, Department of Agriculture, and Corps of Engineers. This additional imagery from previous years was used to determine ensuing shoreline and vegetation changes, as well as extent of marsh deterioration.

Three low-altitude flights were conducted over the area with the NASA-supported ERIM C-47 aircraft. During these flights, multispectral scanner data were collected and supplementary aerial photography was obtained. Mission 54M was flown on 5 May 1972 at flightline altitudes of 610 m and 1220 m. This flight, made early in the growing season, was primarily used for observation of surface water temperature and currents. A second flight at 1220 m was made over the area on 29 August 1972 (Mission 64M) at a time of the year when most vegetation was green. Vegetation was mapped via digital-computer processing of multispectral scanner data taken during this flight. Color infrared photography on 9-in. film was also taken and used for the detailed vegetation classification. A third flight was made on 11 April 1973, just after the peak of the severe flooding along Lake Erie. The resulting imagery was used to map the extent of flood damage to the marsh.

Ground-truth collection comprised the recognition of unidentified objects and areas, detailed surveys of specific areas, and verification or evaluation of the remote sensing interpretation. The ground-truth collector aided the interpreters in their choice and definition of representative areas suited for use as training sets for scanner imagery analysis. To facilitate the accumulation of this information for Pointe Mouillee, several transects were made within the diked portion of the marsh. Vegetation types and height, and bottom contours were noted. After training sets were established and photointerpretation begun, the ground-truth collector aided the interpreters through field identification of unusual objects or patterns which were unclear or not easily discernible.

Before the data processing began, an up-to-date map of Pointe Mouillee was constructed. Since existing USGS maps of Pointe Mouillee do not show the present configuration of the shoreline, this new map was needed for accurate analysis and measurement of marsh areas.

In the data-analysis phase, the data products were used to make quantitative measurements; these measurements, in turn, were applied to make qualitative evaluations concerning the marsh habitat and its management. This included evaluation of vegetation, location of areas deficient in vegetation growth, evaluation of management techniques, and monitoring of the progressive deterioration of the marsh. The data products were also used to evaluate several prospective plans for the marsh, including the acquisition of new lands and the construction of a barrier dike. Details of these analyses are presented in the following sections.

A detailed discussion of the collection and interpretation of photography and the preparation and analysis of vegetation maps of Pointe Mouillee is presented in Ref. [1].

3
VEGETATION INVENTORY

3.1 NEED FOR INVENTORY

One of the major requirements for effective management of any wetlands area is information on the amount and spatial arrangement of useful marsh vegetation. The vegetation is important to waterfowl in two ways—to supply food and to provide protective or escape cover and nesting sites. The arrangement of cover plants, the available food, and proximity to open water are the major factors determining the number of waterfowl and other wildlife a marsh will support—and, to some extent, which species of birds will predominate.

To measure the carrying capacity of a marsh, a thorough, up-to-date inventory of the vegetative cover is important to the game manager, especially if hunting is a major factor. In addition, a vegetation inventory is important in planning management strategies for a marshland, including the clearing of undesirable species and dead vegetation and the introduction or planting of new food types. By serving as benchmark data, the vegetation inventory can also be used to measure the effects of different management practices, such as controlled flooding and draining or clearing and planting. If repeated over a number of years, a vegetation inventory is also the best way of studying ecological succession and, thus, of obtaining some measure of the area's viability as a marsh habitat. To justify its extensive use for the above purposes, the inventory must be readily repeatable at a reasonable cost.

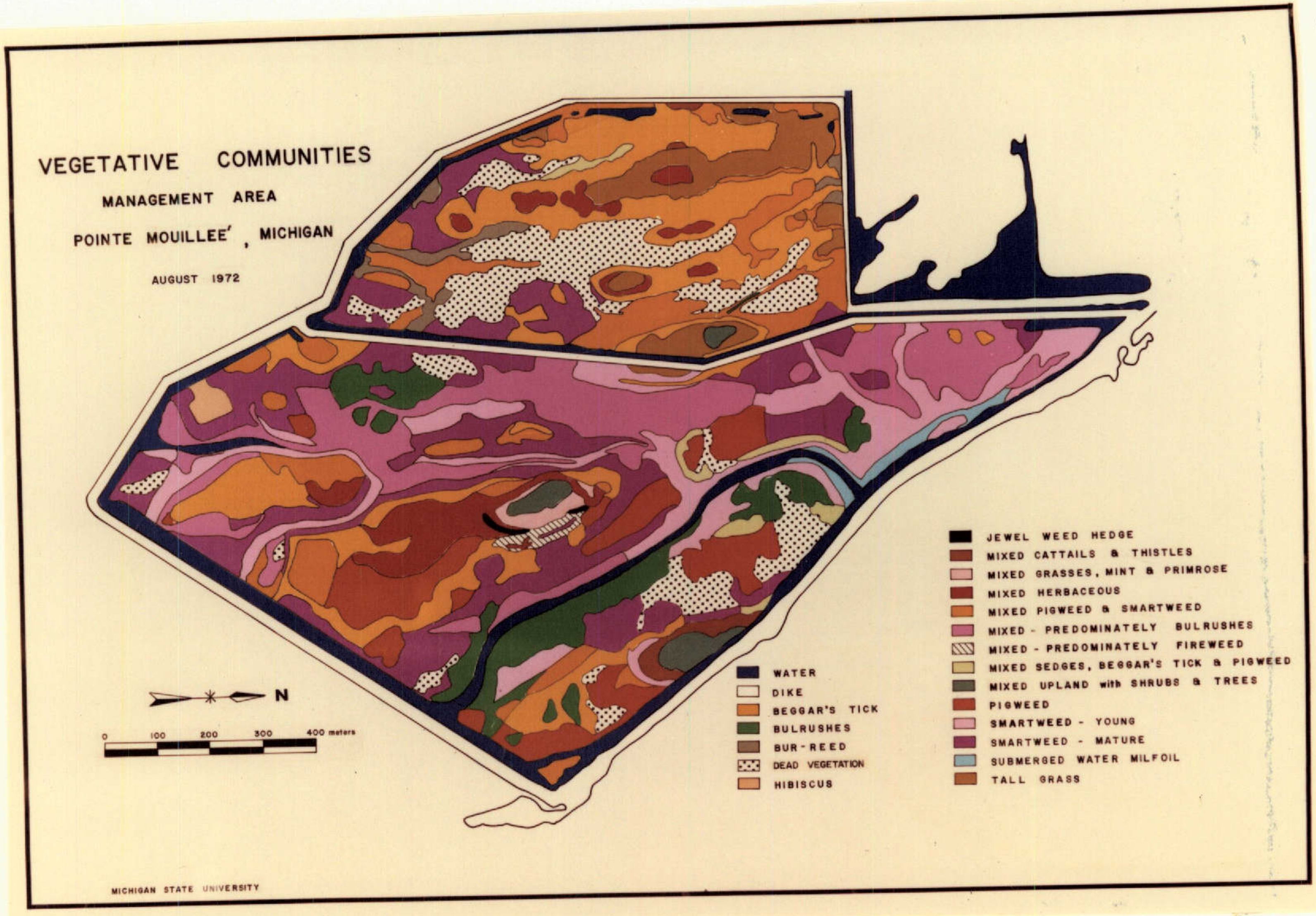
The situation at Pointe Mouillee is typical of many Midwest marshes. Located along two migration routes, the marsh serves mainly as a resting and feeding stop for waterfowl. For this reason, management emphasis is placed on supplying large amounts of quality waterfowl food, with enough cover not only to attract and hold a maximum number of ducks during the fall hunting season, but also to provide for the needs of the birds during the spring migration.

A unique problem at the Pointe Mouillee State Game Area is that the only managed marsh remaining is within the large diked area which has been designated as a wildlife refuge. In order to improve hunting, the game manager must manage the water levels within the diked area for the growth of the proper food plant species. He must also control the predicted yield relative to the estimated amount of cover and food available elsewhere in the marsh. If this is not done, the ducks will spend all their time within the boundaries of the refuge.

Before the initiation of this project, all the management decisions mentioned above were made on the basis of the game manager's intuitive feeling (gained from many years of experience) for how much of what type of vegetation was available for food and cover. The research project demonstrated the utility of an exact and up-to-date inventory of the marsh. Allowing a complete look at the true character of the marsh for the first time, it has revealed certain conditions which were previously unknown to the management staff. More importantly, the inventory replaces subjective guesswork with a quantitative, objective basis for decision making.

3.2 FOOD CROP INVENTORY IN CONTROLLED MANAGEMENT AREA

Vegetation in the diked refuge area was inventoried in two ways. First, a detailed vegetation classification map of the diked area was prepared from aerial photography and intensive field studies (see Fig. 2). Second, a more generalized vegetation map was generated from computer processing of multispectral scanner imagery (see Fig. 3). This second method was later



(73IRO-2-151C)

FIGURE 2. DETAILED VEGETATION MAP OF CONTROLLED FLOODING AREA

(73IRO-1-53C)

Legend	
Dark Green - Smartweed	Light Green - Mixed Grasses
Light Red - Pigweed	Dark Red - Dead Vegetation
Light Blue - Mixed Smartweed and Pigweed	Dark Blue - Water

FIGURE 3. MAP OF FOOD AND COVER VEGETATION IN CONTROLLED FLOODING AREA

extended outside the diked area to map the distribution of cattails and other littoral emergent species. Both maps were applied to management problems.

The detailed classification map of the diked refuge area was prepared by the research staff at Michigan State University. Classification of vegetative cover was derived from 9-in. (23-cm) color-infrared photography at a scale of 1:4000 and the information transferred to an overlay. Nineteen categories of pure or mixed vegetative cover were classified. Identification of plant species was made from two ground transects through the refuge area. These transects were also valuable in determining topography, soil moisture, and other factors which control plant community location. Reference [1] presents a detailed account of the work done by MSU.

Computer analysis of the airborne multispectral data collected over Pointe Mouillee was carried out by ERIM using standard digital-processing procedures (see Appendix). The two different sections of the diked refuge area were processed separately. The larger eastern section is at a lower elevation and, therefore, produces more emergent vegetation. The western section is drier and contains extensive areas of upland grasses. Recognition was performed for classes of vegetation considered important food sources, or for those communities having a large areal extent. These classes included smartweed, pigweed, rushes, and several upland grasses. A complete review of the digital vegetation analysis is included in the Appendix.

3.3 ANALYSIS OF INVENTORY

The spatial correlation of the two maps in Figs. 2 and 3 is readily apparent, especially for the two important general categories—food plants and non-useful upland species. The correlation of areas measured from the two maps is also good, as shown in Table 1.

TABLE 1. VEGETATION CATEGORIES IN CONTROLLED MANAGEMENT AREA

	Area (hectares) (from digital computer map)	Area (hectares) (from detailed photointerpretation map)
Smartweed	37.2	36.8
Other types of suitable vegetation (bulrush, pigweed, smartweed-pigweed mix)	45.6	43.0
Less suitable vegetation (including water and dead areas)	65.8	69.5

Smartweed is considered to be the most valuable food plant available for waterfowl at Pointe Mouillee. For this reason, precise identification is extremely important to game managers. Although the correlation between specific types of vegetation in many cases is not as precise as the correlation between the general categories listed in Table 1, the results show that automatic data processing can provide certain types of useful information as well as conventional interpretation techniques can.

The general conclusion reached from a study of Table 1 is that, at the time of the inventory, almost half of the diked refuge area was covered by unsuitable vegetation and that only one-quarter was covered by smartweed, the most valuable food available. Obviously, there is room for substantial increase in the productivity of the managed area.

3.3.1 DEFICIENT AREAS

Analysis of the vegetation inventory shows two types of deficient (non-productive) areas: areas of dead vegetation, where no growth occurred during the 1972 season, and upland areas supporting grasses, herbs, and brush unsuitable for either waterfowl food or cover. Being able to locate and classify these areas allows the proposal of various management strategies to correct the situation.

The areas of dead vegetation (about 12 hectares in extent) had supported smartweed during the previous year. Various reasons for the subsequent lack of vegetation were discussed with Jim Foote. The explanation he considered most credible was that during the time for smartweed germination, these areas were too deeply flooded. In making the ground transects of the diked area, two separate communites of smartweed were discovered (see Fig. 2). The more mature smartweed community was on relatively high ground; the younger community was found on a plateau about 40 cm lower. It is presumed, since smartweed germinates in 5-8 cm of water, that as the water level in the dike was lowered during the spring, areas at different elevations were colonized in succession as the water reached the proper depth in each. Since most of the dead areas are lower than the surrounding terrain, apparently the water was too deep for smartweed or other plants to germinate.

The existence of upland vegetation areas is another condition of concern to the game manager. Extensive elevated areas of upland grasses and shoals within the game refuge (see Fig. 2) should be eliminated since they are of little value to waterfowl. Two possible alternatives are to increase the winter flooding depth to cover these higher areas, or to cut them down to a lower level. Since deeper flooding may restrict the growth of emergent vegetation in the lower areas, the alternative of earth grading is preferred.

The vegetation inventory indicated to Mr. Foote several large areas of upland grasses (see Fig. 2) and provided, for the first time, an accurate measurement of their size. From this information he can make estimates of the feasibility and costs of various techniques of inducing growth of more suitable vegetation species. Although these areas might need selective seeding to introduce the desired species, they will in all likelihood support emergent vegetation naturally, once flooded to a desirable depth.

3.3.2 FOOD AND COVER

The vegetation inventory also provides quantitative information on the amount and quality of available waterfowl foods. Table 2 is a summary list of the areas of each major type within the diked refuge area. This is the first time such detailed data on Pointe Mouillee resources have ever been produced.

This information can be used in connection with both current management practices and experimental management activities at Pointe Mouillee. These activities should be directed toward determining the relationship of management practices to food and cover production and ultimately to the number of waterfowl using the area. To determine the effectiveness of various management procedures, both current and experimental, a yearly vegetation inventory should be taken of the diked area and the remainder of the marsh. Remote sensing is ideally suited for this. As an alternative, limited information could be provided by a ground-sampling system.

Different water levels and schedules of flooding and drawdown should be tested. In this way, the type and extent of resulting vegetation communities can be related to specific water depths at specific times of year. A continuing record of water levels within the dike should be kept. During flooding and drawdown, frequent measurements should be made at several strategic points within the area, perhaps every six hours. A bottom contour map would also be desirable. Information on the relation of water level to vegetation growth would be of use in predicting seasonal vegetation growth. The knowledge gained would be of importance not only for Pointe Mouillee, but for all managed wetlands.

Experimental seedings with new types of waterfowl food plants should also be attempted. These experiments would aim at offering a variety of food to the ducks and assuring a maximum standing food crop each year.

The data contained in Table 2 will also be useful to Jim Foote as a means of making quantitative estimates of the waterfowl numbers the area can support, based on the type and amount of food available.

3.4 USEFULNESS OF VEGETATION INVENTORY DATA

In the section above, various uses for vegetation inventory data have been discussed. The utility of these applications has been reviewed with Mr. Foote to determine those uses which, in his opinion, offer the greatest potential value to the game manager.

TABLE 2. FOOD IN CONTROLLED MANAGEMENT AREA

Type of Food		Area (hectares)
High Value		
Smartweed		36.8
Submergents (pondweed, duckweed)		0.8
	Subtotal	37.6
Medium Value		
Pigweed		6.5
Smartweed-pigweed mix		12.1
	Subtotal	18.6
Low Value		
Burreed		1.2
Rushes		24.4
	Subtotal	25.6
	Total	81.8

For the situation that existed at Pointe Mouillee during the period of this investigation, practical difficulties limited the opportunity to use the vegetation inventory made of the diked refuge area. The severe flooding during the 1972-73 period caused breaks in the dike that substantially altered the situation for which the inventory was performed.

In spite of these practical difficulties, it is possible to assess the utility of those data which can be provided by remote sensing. In Foote's opinion, the preparation of an inventory with a limited number of classifications is adequate for the purposes of game-habitat management. Separation of vegetation types into trees, lowland vegetation, and upland vegetation is a minimum requirement. For more detailed analysis, it is of value to further classify emergent vegetation into rushes, sedges, and cattails, as well to separately map low emergents.

Repetitive data provided by up-to-date photography would also be valuable in support of short-range studies on which to base management decisions. The time the wildlife manager has available to devote to longer-range studies will determine the type and amount of remote sensing information needed for these studies.

Since it is possible to vary the degree of detail and frequency of repetition in the collection of remote sensing data, the degree to which remote sensing is adopted for habitat management will have to be balanced against the cost of acquiring and analyzing such data. The work at Pointe Mouillee provides a basis for agency personnel responsible for game-area acquisition, development, and management to judge the utility of remote sensing data with respect to their individual information requirements.

4
SHORELINE EROSION AND LOSS OF MARSH HABITAT

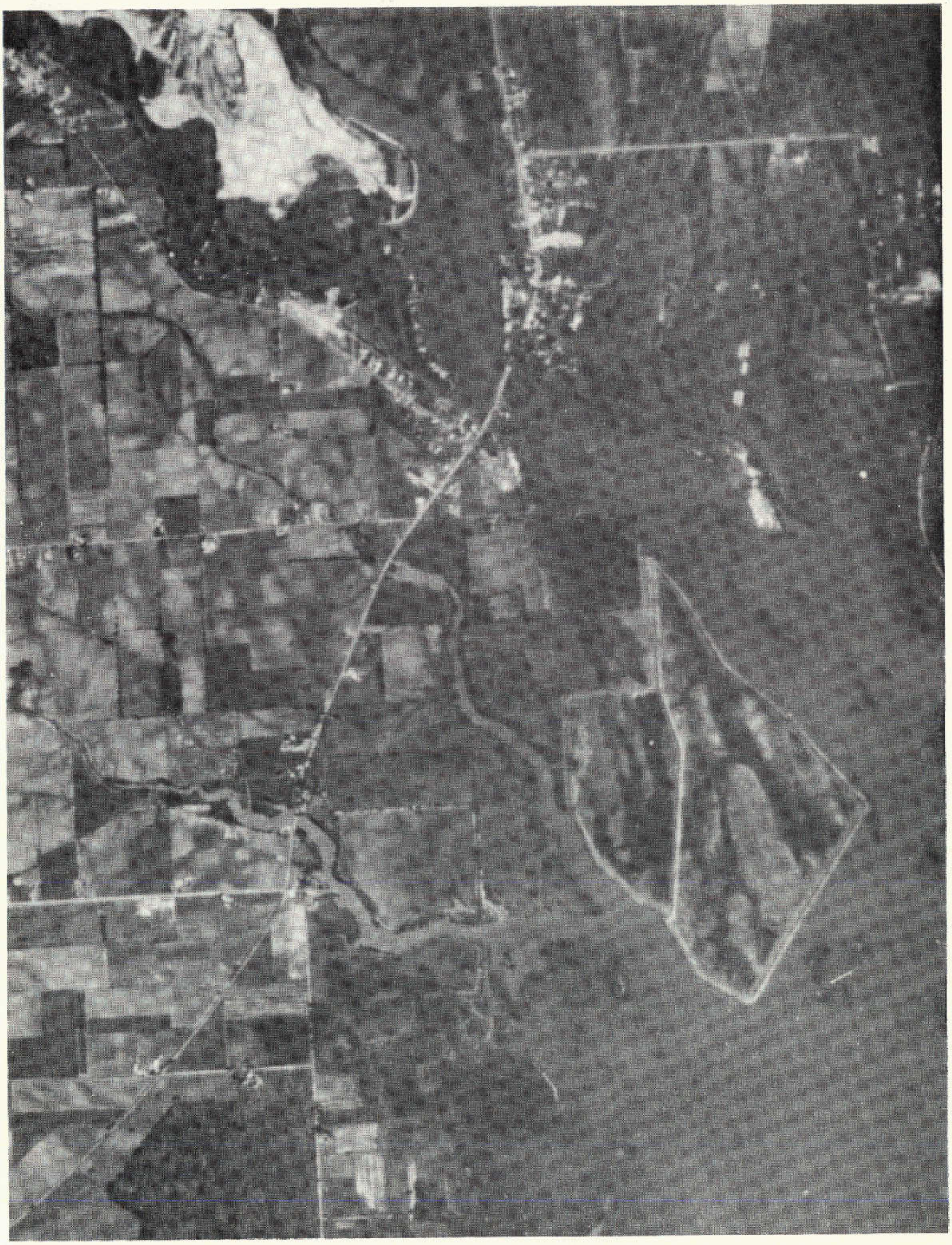
4.1 LONG-TERM CHANGES IN MARSH HABITAT

A chief concern of DNR game managers is the rapid destruction of the marsh delta at the mouth of the Huron River. To determine long-term changes of marsh habitat, a study was made of past records of the area. These records consisted of both aerial photography obtained at various times and bibliographic references on past studies of the area [2]. A series of maps was constructed to depict the change in shoreline configuration over the past four decades.

The appearance of the Pointe Mouillee area in 1935 is shown in Fig. 4. By 1972, the area had changed drastically (see Fig. 5). Measurements taken from area maps indicate that 70 hectares of marsh delta were lost from 1940 to 1967. From 1967 to 1972, an additional 290 hectares were lost. Additional losses were sustained as a result of severe flooding of the western shoreline of Lake Erie during the fall and winter of 1972-73 (see Fig. 6). This flooding was particularly destructive because of the existing high water levels in Lake Erie.

(73IRO-2-132)

FIGURE 4. POINTE MOUILLEE, 1935. Dashed line demarcates present diked area.



(73IRO-2-137C)

FIGURE 5. POINTE MOUILLEE, 1972. Present diked area is at the lower right.

(73IRO-7-559)

FIGURE 6. POINTE MOUILLEE, 11 APRIL 1973

4.2 RECENT STORM DAMAGE

In order to determine the changes caused by recent storms and to inventory the current remaining amount and distribution of marshland, a map of the marsh vegetation of the entire Pointe Mouilee State Game Area and adjacent lands was prepared at the request of Jim Foote. He recommended that measurements be made in terms of four categories: emergent vegetation, upland vegetation, trees, and open water. This breakdown provided sufficient information for making management decisions for the marsh. Figure 7 shows this map.

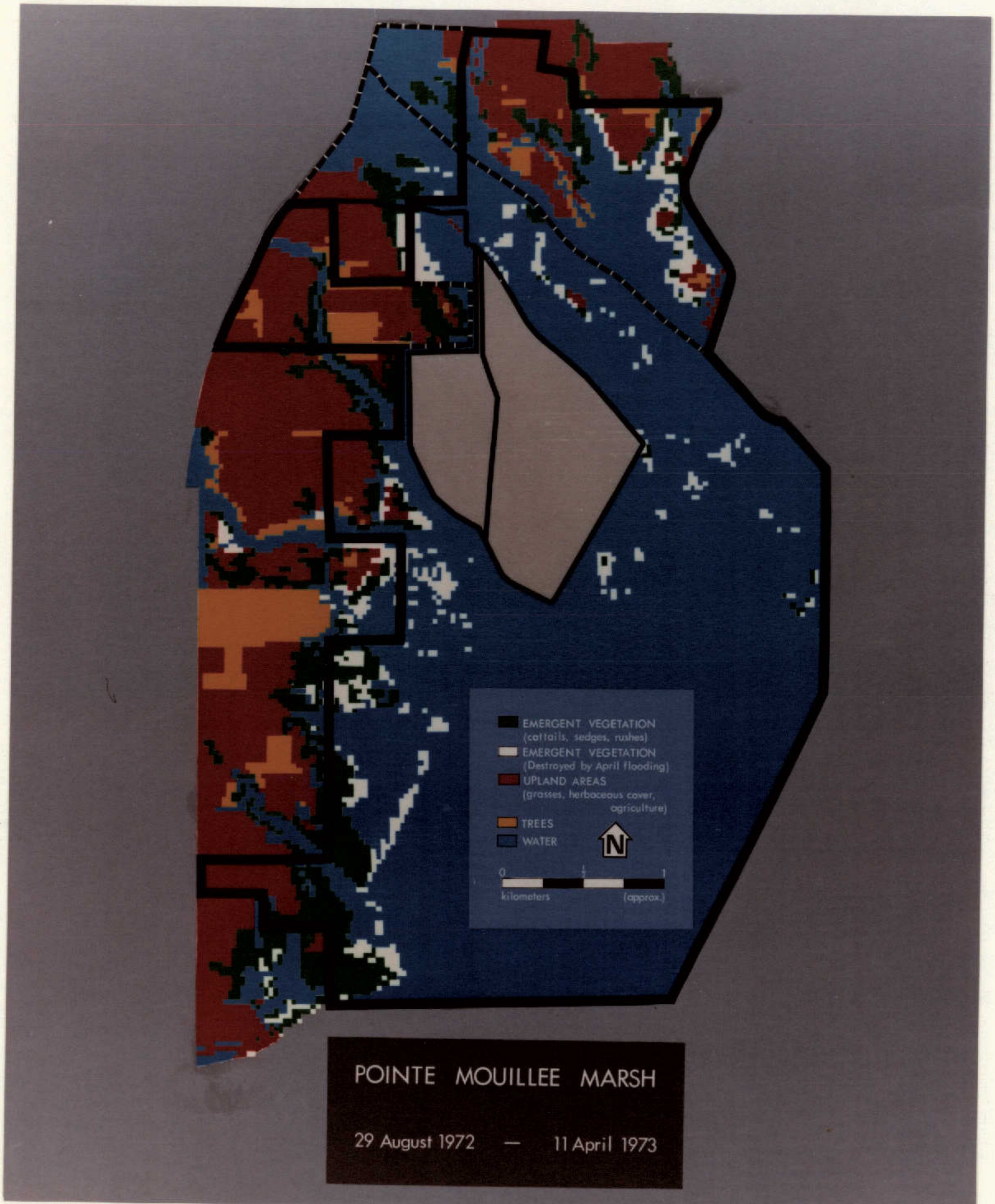
The map was prepared by interpretation of color-infrared photography taken on 29 August 1972 at an altitude of 1220 m. Water and trees were readily distinguished, while separation of the emergent and upland classes of vegetation depended on interpretations of tone, hue, and texture. The area and percent of water as well as of each category of vegetation were determined from this map (see Table 3).

In addition to providing an inventory of the available marsh habitat at Pointe Mouillee as of August 1972, the map was used as a base for comparison with later photography to measure the changes resulting from the spring 1973 flooding. Black-and-white aerial photographs from a 3050 m altitude were taken of the area on 11 April 1973, two days after the peak of the severe spring storm and flooding. The mosaic of the State Game Area shown in Fig. 6 was made from these photographs. A viewgraph of this mosaic was projected onto the marsh vegetation map of August 1972, and the emergent vegetation still remaining was mapped on an overlay. The areas where land and vegetation had been washed away were located by careful comparison with the earlier map. The resulting damage map was then used to determine the acreage and location of emergent vegetation lost during the spring of 1972 (see Table 3).

As can be seen, the storm inflicted severe damage on the Pointe Mouillee marsh. Within the State Game Area itself, more than one-third (37.4 hectares) of the emergent vegetation was washed away. The damage to the adjacent private lands was less severe, mostly because they are farther inland and, thus, protected from the full force of wave action. Still 13.5 percent of the emergent marsh vegetation in these adjacent private lands was washed away.

This measure of storm damage to the marsh is probably higher than any permanent damage, since some emergent vegetation may regenerate itself from root-stocks or seeding. The overall severity of the damage is undeniable, however, and it points out the need for protection of the marsh from direct wave-action.

As a temporary expedient to maintain waterfowl numbers at Pointe Mouillee, hunting pressures should be reduced until the marsh has regenerated from the destruction which took place in 1973. A possibility is to allow hunting only two days per week, as is done on the Erie Club marsh. Even without formal hunting restrictions, hunting will be limited as a result of the destruction of most of the previously existing duck-blind sites.



(73IRO-11-846C)

FIGURE 7. LAND COVER MAP, 1972-73

TABLE 3. MARSH VEGETATION AREAS

	29 August 1972		11 April 1973			
			Area Remaining	Area Lost		
Category*	Area (hectares)	Percent of Total	(hectares)	Hectares	Percent of Emergent	Percent of 29 Aug. Total
State Land North of River						
Emergent	24.4	18.63	15.2	9.2	37.8	7.0
Upland	40.5	30.90				
Trees	5.1	3.88				
Water	61.2	46.59				
Total	131.2					
State Land South of River (includes all cattail islands associated with State Game Area)						
Emergent	80.9	7.86	52.7	28.2	34.9	2.75
Upland	52.2	5.07				
Trees	9.5	.92				
Water	738.6	71.79				
Subtotal	881.2					
Diked Area	147.7	14.36				
Total	1028.9					
All State Land (aggregate of above lands)						
Emergent	105.3	9.07	67.9	37.4	35.6	3.2
Upland	92.7	8.00				
Trees	14.6	1.26				
Water	799.8	68.94				
Subtotal	1012.4					
Diked Area	147.7	12.73				
Total	1160.1					
Adjacent Private Land (East of Roberts Rd and Dixie Hwy and South of Sigler Rd)						
Emergent	69.7	20.9	60.3	9.4	13.5	2.8
Upland	189.0	56.6				
Trees	33.1	9.9				
Water	42.4	12.7				
Total	334.2					

*Marshland Categories (also see Fig. 7)

Emergent vegetation (green) - areas of annual and perennial emergent or flooded soil plants (including cattail, sedge, rush, cane, and arrowhead)

Emergent vegetation (white) - areas destroyed by April flooding

Upland vegetation (red) - areas of perennial or annual dry soil vegetation (including grasses, shrubs, and herbaceous cover), plus cropland

Trees (tan) - areas in which large trees predominate (crowns of 7-m diameter or greater)

Water (blue) - areas of open water—area of the dike is classified separately.

4.3 IMPACT OF PROPOSED SPOIL-DISPOSAL PLAN NORTH OF HURON RIVER

The information on marsh vegetation contained in Table 3 was also used to estimate the amount of marsh habitat which would be affected by the original spoil-disposal plan proposed by the Corps of Engineers. At the invitation of Representatives Anderson and Goemaere of the Michigan House of Representatives, A. N. Sellman (a Research Associate at ERIM) attended a meeting of the Subcommittee on Conservation and Recreation on 3 April 1973 to present some of the results of the Pointe Mouillee work. The Subcommittee was considering House Bill 61, introduced by Representative Kehres of Monroe. This bill would deny the Department of Natural Resources the authority to make available to the Corps of Engineers a section of the Pointe Mouillee marsh for dumping material dredged from the Detroit and Rouge Rivers. The meeting was held for the purpose of allowing the Subcommittee to hear all points of view on the matter.

At the meeting, Sellman was asked whether he would like to express an opinion either for or against the proposed use of the land. He stated that it would be more appropriate to confine his presentation to factual details on the subject. He then described the work being done with NASA support and presented information from the Pointe Mouillee study which had been prepared at the request of Mr. Foote.

The information of particular value consisted of data taken from the photographic records of 29 August 1972 (see Table 3). As is evident from this table, 24.4 hectares of emergent vegetation, out of a total of 253.0 hectares of emergent vegetation and diked refuge area under state ownership, would have been taken over for the dumping site on state land north of the river. Before this information was presented, there was a considerable difference of opinion among individuals speaking to the Subcommittee concerning the magnitude of the areas involved. The information presented by Sellman was useful in quantifying the exact amount of marshland which would be used by the Corps of Engineers and comparing it with the total land in the Pointe Mouillee State Game Area.

4.4 OTHER USES OF REMOTE SENSING DATA

The use of remote sensing for identification and monitoring of extensive losses of barrier islands and cattail beds provides a basis for predicting those marsh-shoreline locations most in need of protection. Another immediate use of the inventory was to delineate the growth of cattails in order to determine what islands and areas are likely to best survive wind and wave action. Areas where little or no shoreline destruction has occurred over the past three decades have been identified; these should be studied further to determine possible reasons for their durability.

More generally, the work described in this section provides the data needed to evaluate and implement proposed DNR actions aimed at countering the pressures arising from natural forces and competing land-use trends in the vicinity of Pointe Mouillee. In Section 5, such data are considered with respect to possible moves to acquire and develop additional land suitable for waterfowl habitat and to protect against further destruction of marshland by providing a barrier dike against Lake Erie.

5
PERPETUATION OF MARSH HABITAT

5.1 OPPORTUNITIES FOR MARSH RESTORATION

The construction of a protective barrier dike is currently being planned jointly by the Michigan Department of Natural Resources and the Army Corps of Engineers. This development would fulfill the requirements of providing for the disposal of material dredged from the navigation channels of the Detroit and Rouge Rivers at a cost comparable to the use of an originally proposed site north of the Huron River. At the same time, the barrier dike is intended to enable regeneration of the marsh and offer other advantages for recreational use [3].

When completely filled with spoil, the facility would form a long, low, curved island, about 4.3 m above Low Water Datum, about 5.5 km long, and 410 m wide. Exterior lakeward dikes would have a clay core with stone face on the lakeward side and top to minimize the effect of wave-action on the dike. The landward dike would be stone-faced on the exterior side to 1.5 m above L.W.D., with the balance of the dike constructed of clay. This barrier dike would buffer the landward marshy shoreline for the purpose of decreasing erosion and water damage and permitting regeneration of marshland and growth of new vegetation. When filling is completed, the 276-hectare surface of the barrier reef would offer opportunity for cultivation of waterfowl foods adjacent to the large regenerated marsh. The plan would also provide for other water-oriented recreational uses in the future.

Once erosion protection is provided by a barrier island, wildlife and fish habitat would be re-established and further improvement in structures would be possible. The size and shape of the shallow open water enclosed by the barrier and the location and shape of the island itself would permit later construction of interior dikes and channels to enable intensive marsh management for waterfowl. By controlling water levels, these features could accelerate re-growth of some parts of the marsh while retarding growth in other areas. With the proper placement of small man-made islands and cattail plantings, the marsh should rejuvenate itself naturally. The upland fields along Roberts Road offer especially good possibilities for creating such controlled management areas.

The Department of Natural Resources is considering the purchase of these lands, which lie to the west of the present State Game Area and to the east of Roberts Road and Dixie Highway. Most of this land is presently unused and subject to frequent flooding. Because of the existing dikes for many of these areas, they can be readily used for intensive management to provide more high-quality waterfowl food and to experiment with new species or new management techniques.

As part of the marsh-habitat-management study, an investigation was made into the requirements for, and the feasibility of, converting these lands into marsh. This conversion would both constitute a more immediate response to the problems facing DNR and nicely complement the longer-range program based on the construction of a barrier dike. Their addition to the Game Area would assure sufficient marshlands during the interim while the outer areas regenerated themselves.

5.2 MARSH HABITAT REQUIREMENTS

The ecological requirements for maintenance of emergent vegetation are as follows: (1) a clay or clayey-muck mineral soil substrate, (2) sufficient soil and water-borne nutrients, and (3) sufficient continuous water depth, or flooding at the proper time of year.

The optimum soil type for different species of vegetation may vary considerably—from sand to muck. Most emergent plants, including the cover and food types common at Pointe Mouillee, grow best in mineral clays. Highly organic soils, because of the low, dissolved-oxygen content of the surrounding waters, are generally poor producers of marsh vegetation, while pure sand is too unfirm a substrate.

Existing soils maps of the region show that most of the land area under consideration for conversion to marsh is covered by a thick horizon of compact loamy clay. Spot checks in the field confirmed this. Since much of the area originally supported marsh vegetation before it was drained for cultivation, this clay soil should prove more than adequate for conversion to marshland.

Nutrient loading of the waters, essential to the growth of emergent vegetation, is generally determined by the characteristics of the watershed area for the marsh. Highly productive farmland in the drainage basin is an indication of good marsh quality, even if the marsh soil types are less than optimum. In the case of Pointe Mouillee, good farmland does exist along the three major feeder streams. Lake Erie itself is also a good source of nutrients. The fact that a highly viable marsh maintained itself previously indicates that lack of nutrients would not be a limiting factor in the creation of new marshlands at Pointe Mouillee.

Since neither soil types nor nutrient levels are limiting factors at Pointe Mouillee, the factor which needs to be stressed is the maintenance of proper water depth for the desired vegetation. In addition, the current vegetation in some areas may present conversion difficulties. This is true in areas of brush and trees, since these would have to be cleared before emergent vegetation could be grown. The undecomposed organic litter which naturally accumulates under this type of cover might also limit vegetation growth for a time.

The fact that a higher water level is all that is needed to convert much of the land in question to marsh vegetation was dramatically pointed out during the spring of 1973. Most of the area was inundated by the high lake levels and severe flooding in March and April. Consequently, many areas of upland vegetation—including one entire partially-diked field just south of Mouillee Creek—now support luxuriant stands of cattail. Several hectares of smartweed are also growing in fields previously covered by grasses.

While current high lake levels are causing many new areas to support emergent vegetation, continued maintenance of these marshlands will require diking. The dike heights necessary will be determined by the detailed topography of each field, but they should be such that a water depth of 0.5 m can be maintained. Many of the fields east of Roberts Road are already partially diked and could be readily converted to marsh.

5.3 RECOMMENDATIONS FOR CONVERSION

The study of lands west of the State Game Area for conversion to marsh habitat has shown that the entire area is physically suited for the production of emergent vegetation. Establishment and maintenance of marsh vegetation in these areas will require that a sufficient water depth be maintained behind man-made dikes. Areas of tree and brush cover would also have to be cleared.

Fields already partially diked should be considered the primary areas for acquisition, since their conversion will require a minimum of time and cost (see Fig. 8). Several of these areas are already covered by emergent vegetation as a result of high lake levels. The areas for primary consideration total 140 hectares.

For secondary consideration as areas for acquisition are those parcels with little or no diking and higher areas with herbaceous cover. These will be more costly to convert to marshland than the fields already diked. In addition, more extensive search must be made to find areas containing the proper subsoils for dike construction; these areas would become borrow pits. The higher upland areas would be most suitable for the cultivation of corn and other crops of special value to geese and other waterfowl. These secondary areas amount to 115 hectares.

Finally, consideration should be given to those areas with forest and woody brush. The cost of clearing such areas is high and the initial production of marsh vegetation low. With a minimum of clearing, the areas of forest cover could be flooded to offer nesting sites and cover for several species of waterfowl. These tertiary areas amount to 27 hectares.

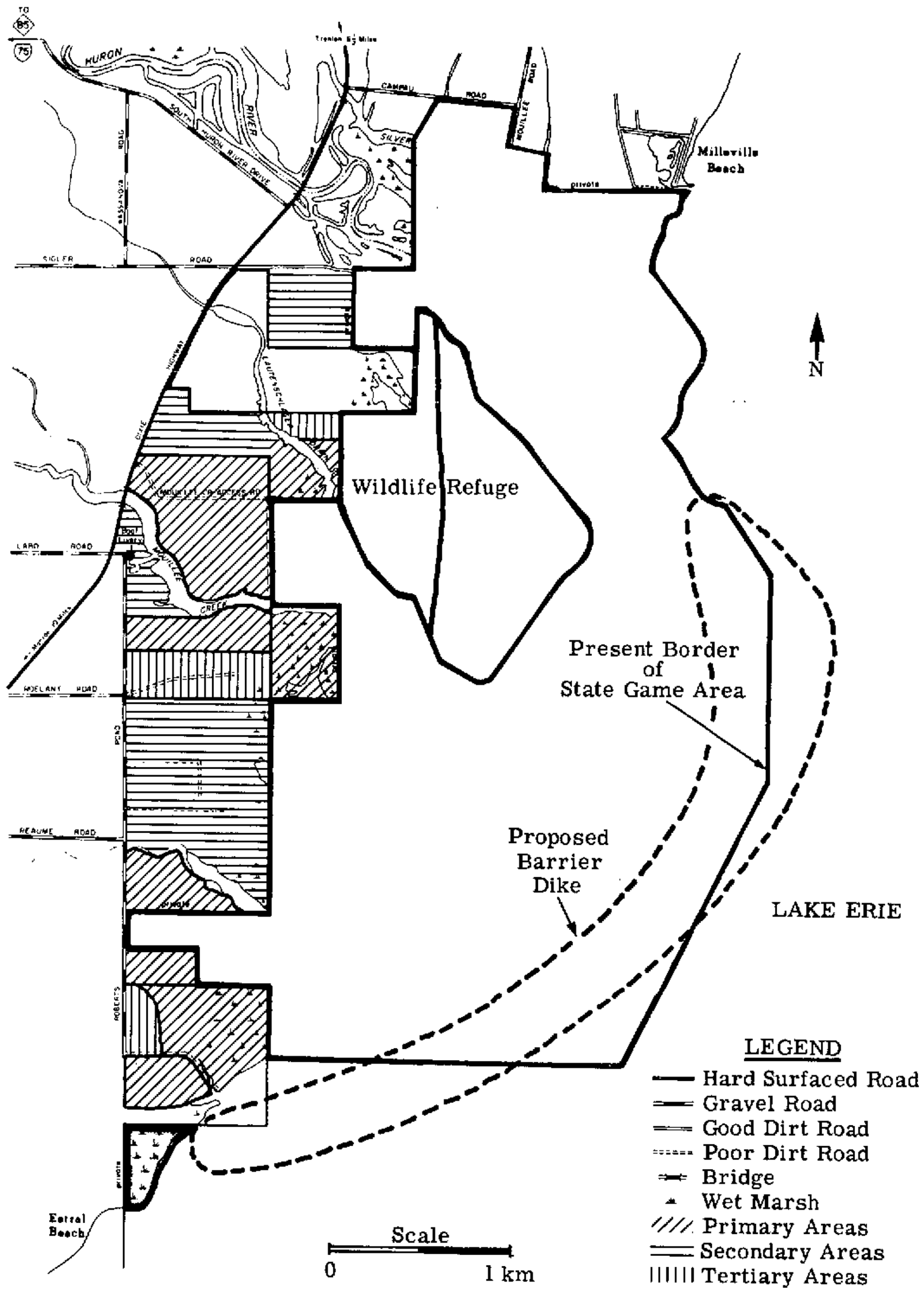


FIGURE 8. POTENTIAL ADDITIONS TO WATERFOWL HABITAT

Although different levels of marsh suitability exist, the entire area of land west of the State Game Area is very well suited for conversion to marsh habitat (1) because of the physical characteristics of the land, and (2) for economic reasons—since the periodic flooding and generally high water table make the land difficult to farm, it is unsuitable for development. Acquisition of all these areas to form a cohesive management unit would greatly enhance the viability of the Pointe Mouillee marsh. Roberts Road is the natural western boundary for the game area, both politically and ecologically. Trespassing complaints by private owners will be alleviated by providing an easily recognizable and visible boundary. The acquisition of these lands will also serve to protect the marsh from undesirable urban encroachment.

Steps should also be taken to ensure that the land west of Roberts Road remains in non-intensive use (e.g., farming, woodlots) by working with local and regional planning bodies. Maintaining such uses will protect the marsh from urban impacts and add to its aesthetic value as a natural area.

A study of the water depths, currents, and sediment patterns within the Pointe Mouillee marsh, both present and projected, should be carried out. This will be necessary for the proper construction of the barrier dike and facilities which will minimize the necessity for future maintenance or channel dredging. The information would also be of great value in predicting the regeneration of the marsh and in planning management strategies accordingly. A continuous reconnaissance of the marsh during and after dike construction is also recommended.

Remote sensing techniques can be used to study the present and projected water circulation patterns, as well as to monitor any environmental effects of the dike construction or inputs of polluted materials. Such monitoring would also serve as a scientific study of the emergence of a new marsh.

6
CONCLUSIONS AND RECOMMENDATIONS

6.1 VEGETATION INVENTORY

A review of the various types of vegetation inventory used at the Pointe Mouillee area indicates that only a moderate amount of informational detail on vegetation cover is generally needed for wildlife-area management purposes.

The minimum amount of detail required includes classification of vegetation into trees, lowland vegetation, and upland vegetation. For areas offering significant waterfowl habitat, emergent vegetation is of particular interest because of its value as cover and food. A further breakdown of emergent vegetation into rushes, sedges, and cattails aids in management decisions. In addition, information is also desired on low emergents, such as pondweeds, milfoil, and water lilies. By confining the vegetation map to those major categories of value to the manager, the cost and time for map preparation can be kept within reasonable limitations. Repeated coverage is desirable to keep the information up-to-date and to spot changes and trends.

In addition to its use for studying the management of a game area, remote sensing imagery and data are useful for keeping both agency officials and the public informed.

Both photointerpretation of color-IR photography and computer processing of multispectral scanner coverage can provide needed data. Photointerpretation with accompanying ground truth is useful for preparing detailed and accurate inventories of many varieties of wetland vegetation [1]. Computer processing of multispectral scanner data produces maps of major groupings of significant food and cover vegetation with an accuracy adequate for many purposes. Computer-processing methods both minimize the amount of ground truth that needs to be collected and provide for rapid and economical automatic interpretation (see Appendix).

6.2 POTENTIAL ADDITIONS TO MARSH HABITAT

Our analysis of land at Pointe Mouillee provides the following information concerning past losses and possible future additions to suitable waterfowl habitat in the area.

Serious losses of marshland have occurred since 1940. Between 1940 and 1967, 70 hectares of marsh delta were lost; then, between 1967 and 1972, this process accelerated, resulting in the further loss of 290 hectares.

Measurements of the photographic coverage made of the area in 1972 indicate the total amounts of land shown in Table 4.

TABLE 4. POINTE MOUILLEE LAND IN 1972

	Area Covered by Desirable Vegetation (hectares)	Total Land Area (hectares)
Diked area	82.8	147.7
Other state-owned land	105.3	212.7
Adjacent privately owned land	69.7	291.8
Totals:	257.8	652.2

High water levels and storms during the fall of 1972 and the spring of 1973 resulted in additional losses of 37.4 hectares of emergent vegetation on state land and 9.4 hectares on adjacent private land.

(total diked area, 147.9 hectares, plus total desirable vegetation on other state-owned land, 105.3 hectares).

A plan originally proposed by the Corps of Engineers to use state land north of the Huron River as a dredge dumping site would have taken 24.4 hectares out of a total of 253.0 hectares of currently suitable state-owned marshland — based on 1972 area totals listed in Table 4

Opportunities exist for increasing the availability of marshland suitable for waterfowl habitat. Approximate values of the areas considered are summarized in Table 5, based on the conditions of August, 1972. By altering management of the diked refuge area, as much as 65 hectares of unsuitable vegetation could be replaced by vegetation useful for food and cover. Other state-owned lands amounting to 107 hectares, which are presently covered by upland vegetation and trees, could be converted to marsh vegetation. In addition, adjacent privately owned lands, which had an area of 282 hectares in 1973, could be acquired East of Roberts Road and Dixie Highway. Of these privately owned lands, 140 hectares already support emergent vegetation or are considered of primary value for conversion, 115 hectares are of secondary value, and 27 hectares of minimal value.

The joint proposal by the Army Corps of Engineers and the Michigan Department of Natural Resources for construction of a barrier dike offshore of Point Mouillee would provide protection against the continuing destruction of existing marshland. In conjunction with the construction of interior diking and water-level control, the protective barrier dike offers the prospect for reversing the destructive process. Besides the existing land areas available for conversion as previously described, this project would provide long-range additions of suitable habitat. Water areas totalling 624 hectares would be afforded protection by the barrier dike and, in part, would revert to marshland. In addition, the barrier dike itself, when filled with dredged material, would offer an additional 276 hectares for use as waterfowl habitat.

Thus, the total additional area which could potentially be converted to suitable waterfowl habitat amounts to nearly 13 sq. km. The type and extent of construction or management required to develop each component of the area, as well as the associated costs, need to be studied further to plan an optimum program.

TABLE 5. AREAS AVAILABLE FOR WATERFOWL HABITAT

Category	Presently Suitable (hectares)	Potential Additions (hectares)
State-Owned Land		
Diked refuge area	83	65
Other	105	107
Privately Owned Land		
Emergent vegetation	70	—
Easy to convert	—	70
Moderate cost to convert	—	115
Expensive to convert	—	27
Water Areas	—	624
Barrier Dike (enclosed surface)	—	276
Totals:	258	1284

Appendix

MULTISPECTRAL SCANNER TECHNIQUES

The airborne multispectral scanner and its associated data-processing equipment were developed for two reasons: to extend the gathering and analyses of remote-sensor information on features of the earth's surface; and to reduce the time and effort devoted to human interpretation of large quantities of imagery.

The use of automated techniques applied to multispectral data to provide information for waterfowl-habitat assessment is described below. Results shown in Fig. 3 are illustrative of the current state-of-the-art in the use of scanner data. Research in these methods under other programs is aimed at improving resource-mapping reliability and reducing the time and cost of obtaining the final product.

Computer processing of multispectral data is designed to identify and map various types of features in a scene by using information from a number of spectral bands (i.e., wavelength ranges). The multispectral scanner (MSS) extends the ability to record an image in the visible range, over which the human eye is sensitive, to invisible ultraviolet and infrared regions of the radiation spectrum. The MSS divides this spectral region, from 0.32 to 13.5 μm, into a number of discrete bands. Thus, in the visible region the MSS supplies significant spectral detail, some of which may not be discernible to the eye. In addition, reflectance and emittance (temperature) information is recorded from the infrared portion of the spectrum.

The value of additional spectral information is analogous to the increased ability to identify correctly and map crops or soils by means of color photography rather than black-and-white [4]. Black-and-white photography records information in a single spectral band and color film uses three bands; the MSS, on the other hand, records up to 12 bands of spectral information [5].

The difference between automated processing of MSS data and conventional human photointerpretation should be noted. The photointerpreter identifies surfaces or objects in an image on the basis of his knowledge of scene characteristics—including color, shape, texture, size, pattern, and relationship of ground features. Processing of MSS data substitutes for this variety of identification parameters the recognition of features by detailed statistical spectral analysis. In other words, only the single parameter of scene radiation is used in computer identification of features.

Previous studies indicate a wide variety of surfaces which may be separately mapped by computer [6-12]. Because the method is a statistical one, based on the uniqueness of terrain spectral characteristics, some classification error occurs because of natural variations of terrain surfaces. As with photointerpretation, the operational use of this method requires that identification and mapping errors remain within acceptable limits.

Scene information obtained by a MSS can be played back from recorded magnetic tape in a number of forms. The simplest is a set of photo-like images, each showing the scene in one spectral band. These may be visually analyzed using photointerpretation techniques. The computer acts as a filter to reduce the amount of information presented to the analyst or user. One form of processing is that of level slicing. A single channel of data is divided into two or more increments on the basis of signal levels in that band representing the lightness or darkness of the scene surface or feature. The technique is somewhat similar to film densitometry, except that the scene information is taken directly from magnetic tape rather than from a film base. Surface water mapping, for example, can be accomplished by processing a single channel (1.5 to 1.8 μm near-infrared band) recorded on magnetic tape. Because the reflectance of solar radiation in this band is low, surface water can be distinguished from other surfaces by printing out only areas in which the tape signal falls below a certain level.

A second technique, ratio processing, determines the ratio of radiances in two spectral bands. Thus, only relative radiance differences between the two bands are displayed. This technique produces an enhanced image in which vegetation or other surfaces may appear in greater contrast than on the two original images. Subsequently, level slicing may be performed to divide the ratioed data into discrete ranges. Both level slicing and ratio processing are relatively simple and economical. In addition, they are essentially unsupervised classification techniques which require no a priori information in the form of training samples.

A third approach uses several channels of data simultaneously and spectral information from selected sample areas. With this technique, the user selects training sets—that is, sample areas on the ground that are typical of the different types of surfaces he wishes the computer to map. The computer is programmed to analyze and remember the spectral characteristics for the training sets. Then the MSS data for the entire scene is run through the computer. The computer rapidly compares the spectral characteristics from each resolution element in up to 12 bands with those of the training sets. For those resolution elements found similar to a given training set, the computer prints out a single recognition image. The process is repeated for each type of surface represented by a sample training set or combination of training sets. Each recognition image may be examined individually, or several images may be combined into a composite image-map in which different colors or symbols represent different recognition classes.

Computer analysis of the multispectral data acquired over Pointe Mouillee on 29 August 1972 was carried out using the last of the processing procedures outlined above implemented on a digital computer. The primary purpose of this analysis was to provide a vegetation map showing classes of vegetation which can be considered sources of waterfowl food or cover.

The initial recognition efforts utilized training sets from within a transect made in the eastern diked area. The recognition results for (1) pigweed, (2) smartweed and (3) a mix of pigweed and smartweed corresponded very well with both the ground truth and photography for the area of the transect only. The other areas were primarily recognized as smartweed. The signatures for Mix A and Mix B, rush, and dead 1 which were taken from the transect worked well in recognizing similar areas outside the transect (see Fig. 9 and Table 6).

To refine the signature for smartweed, a composite signature was constructed using three training sets, two of which were from outside the transect. The two pigweed signatures from within the transect were also combined. An analysis of the subsequent recognition map indicated a better differentiation between pigweed and smartweed but did not improve recognition of smartweed as interpreted from the photography. At this point, a signature for a sparse pigweed and smartweed mix was introduced. This enabled the recognition of areas of less abundant vegetation (where more bare ground is visible) and eliminated the over-recognition of smartweed.

At a higher elevation than the eastern diked area, the western diked area is drier with extensive areas of upland grasses and relatively little smartweed or pigweed. Training sets were selected, therefore, from the transect across the western diked area, rather than being repeated from the eastern section. These sets included three grasses, an upland mix, and dead vegetation. In several instances the training-set areas were extended away from the transect areas to utilize a larger and more uniform test area.

Two signatures were necessary for recognition of cattails. One, taken from an offshore cattail island, recognized these islands as well as cattails along the shoreline. Thus, the first signature was useful in defining the land-water boundaries along Mouillee Creek and Lautenschlager Drain. The second cattail signature, taken from the western edge of the dike, recognized the dry-land cattails.

Use of signatures for reliable recognition of water within the diked area presented a major problem. Variability in the depth and turbidity of the water and in its vegetation content caused water signatures to recognize only the training set area; then, when a composite signature was used, large vegetated areas were recognized as well. We found, however, that water areas within the dike could be mapped fairly well using one level of channel 10 (2.0 to 2.6 μm). Water outside the dike was recognized by means of a composite signature.

When a separate signature for sedges was added to the two used for cattails, these categories were identified along the entire shoreline of the game area. The recognition was useful in defining the wetland boundaries and in evaluating the area for habitat quality [13].

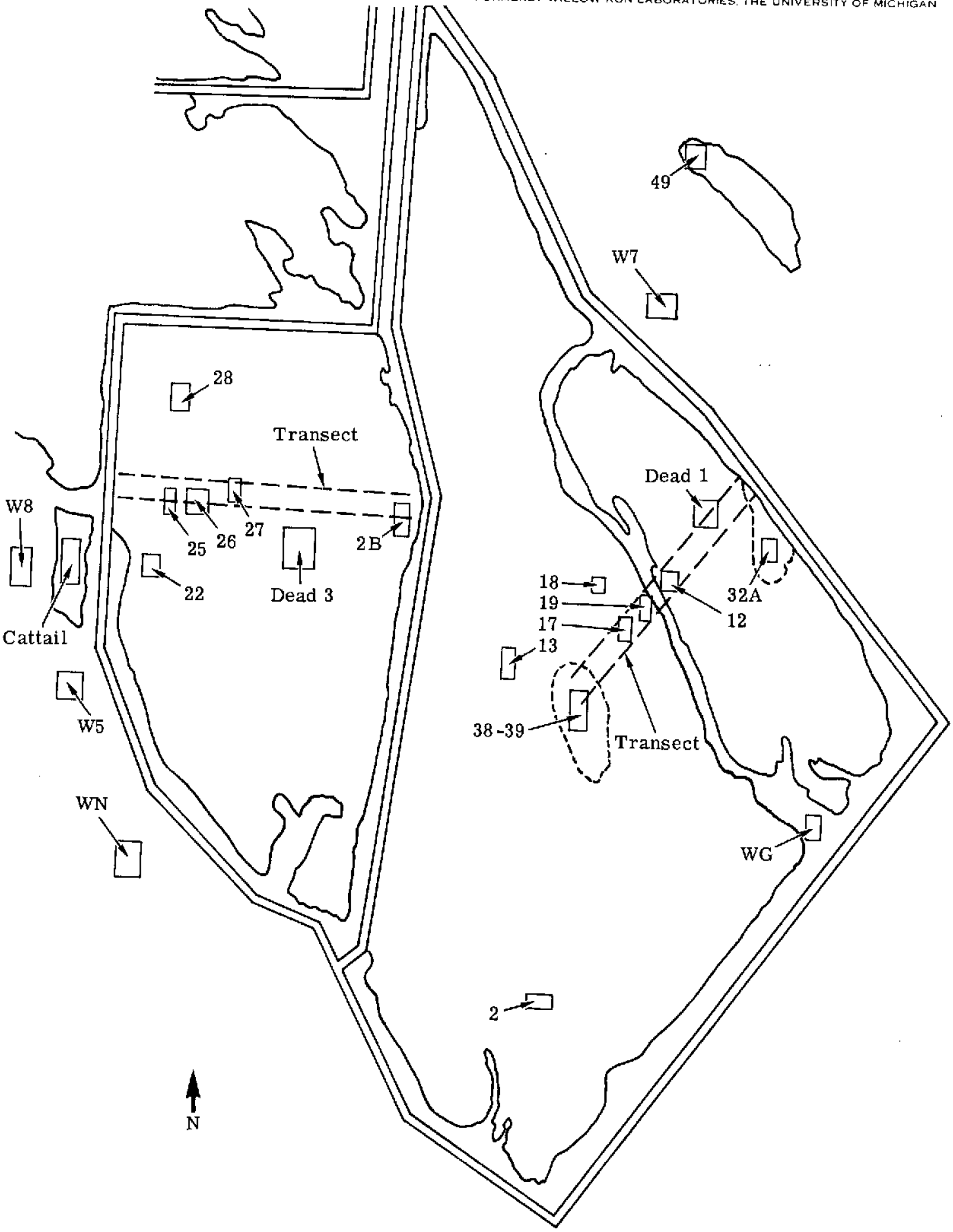


FIGURE 9. TRAINING SET LOCATIONS FOR MULTISPECTRAL SCANNER RECOGNITION MAP

TABLE 6. DIGITAL TRAINING SETS USED IN MAKING RECOGNITION MAP

Classification	Signature Used
Deep Water	WN, WG, W5, W7, W8
Mix A	32
Dead 1	Dead 1
Rush	I2
Pigweed	17, 18
Smartweed	19, 2, 13
Mix B	38 - 39
Mix C	2B
Dead 3	Dead 3
Grass 1	27, 28
Grass 2	26, 25
Grass 3	22
Cattail	Cattail, 49

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